GARMIN

GTS Traffic Systems

Pilot's Guide

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B	3/21/14	Added new GTS models and reorganized/edited content.

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WARNINGS AND CAUTIONS

***WARNING**: The GTS TAS and TCAS I systems are intended for advisory use only to aid the pilot in visually acquiring traffic. No avoidance maneuvers should be based solely upon traffic information. It is the responsibility of the pilot in command to see and maneuver to avoid traffic.*

***CAUTION**: Pilots should be aware of TAS/TCAS I system limitations. TAS/TCAS I systems require intruder transponders to respond to system interrogations. If an intruder transponder does not respond to interrogations due to antenna shading or marginal transponder performance, it will not be displayed, or display may be intermittent. Pilots should remain vigilant for traffic at all times when using TAS/TCAS I systems for non-transponder equipped airplanes or unresponsive airplanes.*

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SYSTEM DESCRIPTION

Garmin GTS Traffic Systems are a family of Traffic Advisory Systems (TAS) and Traffic Alert and Collision Avoidance Systems (TCAS). The systems feature both active interrogation of aircraft transponders and passive surveillance of 1090 MHz Extended Squitter ADS-B broadcasts (1090ES).

GTS Traffic Systems include the following products:

- GTS 800 TAS
- GTS 820 TAS and GTS 850 TCAS I
- GTS 825 TAS and GTS 825 TCAS I
- GTS 8000 TCAS II

Terms used in this Pilot's Guide:

- TAS: Refers to any TAS system (GTS 800/820/825)
- TCAS I: Refers to any TCAS I system (GTS 850/855)
- TAS / TCAS I: Refers to any TAS or TCAS I system (GTS 800/820/825/850/855)
- TCAS II: Refers to the GTS 8000

NOTE: *Details on the GTS 8000 TCAS II operation are not included in this guide. For information on a GTS 8000 TCAS II system, refer to the aircraft-specific installation documentation.*

General Theory of Operation

Active Surveillance

GTS Traffic Systems actively interrogate the transponders of other nearby aircraft to determine their bearing, distance, altitude and vertical trend relative to your aircraft. Aircraft with operating transponders are detected, and aircraft with altitude reporting transponders will also include altitude and vertical trend information (level, climbing, or descending). This information is then shown on a compatible traffic display.

GTS Traffic Systems also provide visual and aural alerts to assist in visually acquiring traffic. Aural and visual alerts are provided as a Traffic Advisory (TA) for conflicting traffic.

Passive Surveillance

GTS Traffic Systems can optionally utilize passive surveillance information from an internal ADS-B receiver. The ADS-B receiver uses 1090ES broadcasts from other aircraft that are equipped with 1090ES ADS-B Out. These broadcasts are combined with the active surveillance data to enhance the accuracy of target positions on the display. This is Garmin's CLEAR CAS™ technology, which correlates ADS-B and actively interrogated targets to provide pilots with the most accurate target position. A GPS position source and magnetic heading system are required for passive surveillance functionality.

System Specifications

The specifications for each member of the GTS Traffic Systems family are contained in the table below.

Product	GTS 800	GTS 820	GTS 825	GTS 850	GTS 855
Type	TAS TSO-C147 (Class A)	TAS TSO-C147 (Class A)	TAS TSO-C147 (Class A)	TCAS I TSO-C118	TCAS I TSO-C118
ADS-B Capability	TSO-C166b [Note 1]	TSO-C166b [Note 1]	TSO-C166b [Note 1]	TSO-C166b [Note 1]	TSO-C166b [Note 1]
Transmit Power	40 Watts	250 Watts	400 Watts	250 Watts	400 Watts
Maximum Range	22 NM	40 NM	40 NM	40 NM	80 NM
# Targets Tracked	45	75	75	75	75
XPDR Interface Required	None	Mode S [Note 2]	Mode S [Note 2]	Mode S [Note 2]	Mode S [Note 2]
External Amplifier Required	No	Yes	No	Yes	No

Table 2 GTS Traffic Systems Specifications

Note 1: Class A1 / Type 1 (Class A1S for single-antenna installations). GTS 800/820/850 require system software version 3.00 or later for TSO-C166b compliance.

Note 2: A compatible Garmin transponder capable of identifying TCAS interrogations is required.

System Components

System Processor

Each GTS Traffic System includes a system processor. The system processor connects to all of the required and optional antennas, displays, controls, and aircraft interfaces.

Figure 1 GTS System Processor

GTS 800/820/850 System Processors

The GTS 800/820/850 systems use a unique system processor. The GTS 800 system processor is different from a GTS 820 or GTS 850 system processor.

GTS 825/855 System Processor

The GTS 825/855 systems share a common system processor known as the "GTS Processor." The GTS Processor can be configured during installation to be either a GTS 825 TAS or a GTS 855 TCAS I.

Antennas

The GTS Traffic Systems use one or two dedicated externally-mounted antennas to transmit transponder interrogations to other aircraft. The same antenna or antennas are used to receive transponder replies and ADS-B broadcasts from other aircraft.

A directional antenna on top of the aircraft is always required and is used to determine the bearing to the intruder aircraft. Interrogations transmitted from the top antenna are directional, which reduces the number of transponders that reply to the interrogation and reduces congestion on the 1090 MHz frequency.

An optional second antenna may be installed on the bottom of the aircraft to improve performance. A bottom mounted antenna adds additional visibility for targets that could be shaded from the top antenna (for example, targets that are underneath the aircraft). The bottom antenna may be a directional antenna or an omni-directional antenna. If a directional antenna is installed on the bottom, it may be used to determine the bearing to the intruder aircraft (omni-directional antennas cannot determine bearing). The bearing accuracy of a bottom directional antenna on a fixed gear airplane may be less than that of the top antenna, due to the presence of the landing gear. Bearing from the bottom antenna on a retractable gear airplane is not used when the landing gear is extended. Interrogations transmitted from the bottom antenna are always omni-directional, regardless of the antenna type.

Directional Antennas

GA 58 Directional Antenna

The GA 58 is a directional four-element antenna that may be installed on the top and/or bottom of the aircraft.

Figure 2 GA 58 Directional Antenna

Sensor Systems Low-Profile Antenna

Sensor Systems antennas are low-profile directional antennas that may be installed on the top and/or bottom of the aircraft.

Figure 3 Sensor Systems Low-Profile Directional Antenna

Omni-Directional Antenna

Numerous omni-directional (monopole) antennas are suitable for installation on the bottom of the aircraft. Omni-directional antennas cannot determine the bearing to an intruder aircraft.

Figure 4 Bottom-Mounted Omni-Directional (Monopole) Antenna

External Amplifier

GPA 65 Amplifier Module (GTS 820 & 850 only)

The GPA 65 is a combined Power Amplifier and Low Noise Amplifier that is required for use with the GTS 820 and GTS 850 systems only.

Figure 5 GPA 65 PA/LNA Module

System Interfaces

The GTS Traffic System includes interfaces to various required and optional aircraft systems.

Altitude Source

At least one pressure altitude source is required for system operation. The pressure altitude source is compared to the pressure altitude replies from other aircraft to calculate their relative altitudes. Pressure altitude interfaces are available from a serial altitude encoder or digital air data computer.

Transponder Interface

All GTS Traffic Systems except the GTS 800 require an interface to a compatible Mode S transponder. The transponder interface allows the high-power GTS systems to determine how many TCAS-equipped aircraft are in the area. To reduce frequency congestion, transmit power is adjusted based on the number of other TCAS-equipped aircraft in the area. The GTS 800 systems transmit at a lower power level and do not require a transponder interface.

Traffic Display

At least one traffic display is required, and multiple traffic displays are supported. The traffic display shows a two-dimensional (top-down) view of traffic that is detected by the GTS system. Bearing, distance, relative altitude, and vertical trend can be depicted on the traffic display. Some traffic displays include integrated controls for selecting the system operating mode and altitude filter. For details on the capabilities of a compatible traffic display, refer to the documentation for that display.

Contact your Garmin dealer to learn which displays are compatible with the GTS systems. Some displays may require the purchase and installation of additional modules and/or software.

Audio System

The GTS must be interfaced to an audio system so that traffic advisory aural alerts and self-test messages can be heard by the crew.

Landing Gear Position

Landing gear position for retractable gear aircraft is interfaced to the GTS system. Landing gear position may be used to mute traffic advisory audio, adjust the sensitivity of traffic alerts, or compensate a bottom directional antenna.

Radar Altimeter

A radar altimeter may be optionally interfaced to the GTS system. Radar altimeter height may be used to mute traffic advisory audio, adjust the sensitivity of traffic alerts, or filter out traffic targets that are on/near the ground.

GPS

GPS is an optional interface to the GTS system that can provide position, groundspeed, and altitude (GPS-calculated). GPS input may be used to enable several functions, including ADS-B In, automatic air/ground determination, or calculated height above ground.

Magnetic Heading

Magnetic heading is an optional interface to the GTS system. Magnetic heading may be used to correct the bearing of traffic targets during turns, and it is also needed to enable the ADS-B In function. Magnetic heading interfaces are available from analog gyro systems or digital AHRS.

Air/Ground Switch

An air/ground switch (e.g. squat or airspeed switch) is an optional interface to the GTS system which may be used for automatic air/ground determination.

Control Switches

The GTS system supports external switches for selecting the operating mode (operate/standby), initiating a self-test, or canceling/muting traffic advisories. Use of external switches is required with certain traffic displays that do not include integrated controls. External switches, when installed, are a momentary pushbutton type.

Operating Modes

The system typically powers up in Standby mode. In Standby mode, the system is powered on, but no traffic surveillance functions are performed.

Operate mode is the normal mode for operations. All active and passive traffic surveillance functions are performed in Operate mode.

Self-test mode is a manually-selected mode that briefly performs a test of the system. Refer to the self-test section of this guide for additional information.

If the system detects a fault that will prevent normal operation, the system will enter and remain in Fail mode.

Control of Modes

Standby, Operate, and Self-test modes may be manually selected via system controls. The controls are either integrated with the traffic display(s) or installed as external control switches.

Traffic Information

The function of the GTS Traffic System is to provide information regarding nearby traffic to the crew. For each traffic target that is tracked by the GTS, the system computes the bearing, range, relative altitude, and vertical trend for the target. Relative altitude and vertical trend are available for targets with altitude reporting capability. This traffic information is displayed to the crew on an interfaced display. Bearing and range are shown on a two-dimensional (top-down) map. Relative altitude, when available, is displayed above or below the corresponding target symbol in hundreds of feet. When the target is above the own aircraft, it is preceded by a "+" symbol; a minus sign "-" indicates the target is below the own aircraft. A vertical trend arrow to the right of the intruder symbol indicates climbing or descending traffic with an upward or downward-pointing arrow.

Figure 6 Example Traffic Display

NOTE: *Always refer to the traffic display documentation for details on how traffic information is depicted on each display.*

Other Traffic (OT)

Other Traffic (OT) targets are typically displayed as a hollow diamond and do not meet the criteria for any other traffic type.

Proximity Advisories (PA)

Proximity Advisory (PA) targets are typically displayed as a solid diamond. PAs are defined as traffic within 6 NM horizontally and 1200 feet vertically that are not a Traffic Advisory.

Traffic Advisories (TA)

Traffic Advisory (TA) targets are typically displayed as a yellow circle and are generated when the GTS predicts that a target may pose a collision threat. Traffic Advisory sensitivity, criteria, and types are described in the following sections.

Sensitivity Level

To prevent nuisance TAs in the airport environment, there are two sensitivity levels available: Sensitivity Level A (SL A) and Sensitivity Level B (SL B). The Sensitivity Level determines what criteria will be used for TAs. SL A is less sensitive and traffic must be closer before it will generate an alert. SL B is more sensitive and traffic may be farther away to generate an alert. The logic for

choosing the sensitivity level is based on available system inputs. If none of the inputs described below are available, the system will always remain in the most sensitive level, SL B.

Radar Altimeter

If the aircraft is equipped with a radar altimeter, SL A will be used when the radar altitude is less than 2,000 feet. SL B will be used when the radar altitude is greater than 2,000 feet.

Landing Gear Position

If the aircraft has retractable landing gear, SL A will be used when the landing gear is extended. SL B will be used when the landing gear is retracted. Landing gear position does not affect sensitivity level if a radar altimeter is available.

Groundspeed

GPS groundspeed may be used to select the sensitivity level only if radar altimeter and landing gear position is not available. SL A will be used when the groundspeed is less than 120 knots. SL B will be used when the groundspeed is greater than 120 knots.

No Available Inputs

If none of the above inputs is available (radar altimeter, landing gear position, or groundspeed), the system will always remain in the most sensitive level, SL B.

TA Criteria

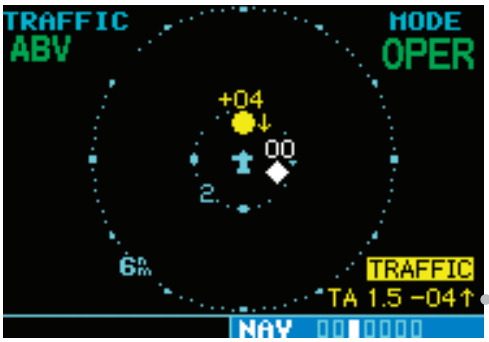
Targets may become a TA based on closure rate (time until collision) or if they encroach within a minimum distance. The criteria used depend on the current sensitivity level and whether the target has altitude reporting capability. Once a TA is generated, it will remain a TA for at least 8 seconds, even if the target no longer satisfies the criteria for a TA. The following table summarizes the criteria used for TAs.

Sensitivity Level	Intruder Altitude Available	TA Alerting Conditions
A	Yes	Intruder closing rate provides less than 20 seconds of vertical and horizontal separation. Or: Intruder closing rate provides less than 20 seconds of horizontal separation and vertical separation is within 600 feet. Or: Intruder range is within 0.2 NM and vertical separation is within 600 feet.
A	No	Intruder closing rate provides less than 15 seconds of separation or intruder range is within 0.2 NM.
B	Yes	Intruder closing rate provides less than 30 seconds of vertical and horizontal separation. Or: Intruder closing rate provides less than 30 seconds of horizontal separation and vertical separation is within 800 feet. Or: Intruder range is within 0.55 NM and vertical separation is within 800 feet.
B	No	Intruder closing rate provides less than 20 seconds of separation or intruder range is within 0.55 NM.

Table 5 TA Alerting Criteria

No-Bearing TAs

If the bearing of a TA target cannot be determined, a No-Bearing TA will be issued. No-Bearing TAs are typically displayed as a yellow text banner on the traffic display. The text typically includes "TA" followed by the distance, relative altitude, and vertical trend arrow. Relative altitude and vertical trend arrow are not available for targets without altitude reporting.



No-Bearing TA Traffic Annunciation

Figure 7 No-Bearing TA

Off-Scale TAs

If a TA is beyond the currently-selected traffic display range, it is typically shown with a half-circle icon at the edge of the display range. Refer to the traffic display documentation for details regarding off-scale TA depictions.

TA Aural Alerts

When a target becomes a TA, an aural alert message is played to advise the crew. The aural alert may include an ATC-description of the target's bearing, altitude, and distance. For example, "Traffic! One o'clock, High, Two miles."

The aural alert format is shown in the table below:

Bearing	Relative Altitude	Distance
"One o'clock" through "Twelve o'clock" or "No Bearing"	"High", "Low", "Same Altitude" (if within 200 feet of own altitude), or "Altitude not available"	"Less than one mile", "One Mile" through "Ten Miles", or "More than ten miles"

Table 6 Aural Alerts

Optionally, TA aural alerts may be shortened under some circumstances. A TA aural alert may be shortened to "Traffic, Traffic!" in the following cases:

- Another TA is already present, or
- The range to the TA target is less than 0.25 NM

NOTE: Shortened TA aural alerts are currently only available in GTS 825 and GTS 855 systems with system software version 2.20 or later.

TA Aural Muting

TA aural alerts may be muted or canceled under some circumstances. Muting or canceling of the TA aural alert does not affect the visual display of the TA.

Radar Altimeter

If the aircraft is equipped with a radar altimeter, all TA aural alerts will be muted when the radar altitude is less than 400 feet.

Landing Gear Position

If the aircraft has retractable landing gear, all TA aural alerts will be muted when the landing gear is extended. Landing gear position does not mute TA aural alerts if a radar altimeter is available.

TAWS/Windshear Alerts

TA aural alerts may be temporarily muted by higher-priority aural alerts, such as TAWS or windshear. The TA aural alert will resume when the higher-priority aural alert is no longer active.

External Switch

A TA aural alert may be canceled with an optional momentary pushbutton switch. Pressing this switch during a TA aural alert will cancel/mute that aural alert. Subsequent TA aural alerts will be played, and the switch must be pressed each time that it is desired to cancel/mute a TA aural alert.

Ownship Air/Ground Detection

Optional external interfaces can be used to determine whether the ownship is on the ground or in the air. Interfaces that may be used for determining the air/ground state include:

- An air/ground switch (e.g. squat or airspeed switch).
- GPS groundspeed. Greater than 35 knots indicates in air, and less than 30 knots indicates on ground.
- Air/ground Ethernet message from a Garmin avionics system.

Ownship air/ground detection is used for the automatic mode switching and calculated height above ground features.

Automatic Mode Switching

The system can automatically switch between Operate and Standby modes based on whether the ownship is in the air or on the ground. The system will automatically select Operate mode 8 seconds after becoming airborne. Standby mode will automatically be selected 24 seconds after landing.

Calculated Height Above Ground

For aircraft that are not equipped with a radar altimeter, the system can calculate the height above ground using information from various optional interfaces. This calculation can enable additional functionality (such as ground traffic filtering), without requiring a radar altimeter interface.

Height above ground can be calculated using an internal airport database and optional 3-D GPS interface. The system's internal airport database contains locations and elevations for airports throughout the world. By comparing the 3-D GPS position and altitude to the airport database, the ownship's height above ground can be calculated. If GPS altitude is not available, 2-D GPS input (position only) can be used along with baro-corrected altitude from an air data computer to perform the calculation.

Additionally, if the system has detected that it is on the ground, the on-ground position and pressure altitude will be used as a known ground reference point. If GPS position is not available, the on-ground altitude will still be used as a reference point as long as the ownship is on the ground and for up to 60 seconds after takeoff.

NOTE: The Calculated Height Above Ground feature is only available in GTS 825 and GTS 855 systems with system software version 2.20 or later.

Ground Traffic Filtering

To reduce nuisance alerts and reduce traffic display clutter, traffic that is on or near the ground may not be shown on the traffic display or generate traffic alerts. There are several methods used for filtering out ground traffic.

Mode S Targets

Mode S transponders include in their replies an indication of whether the aircraft is on the ground or in the air. Mode S traffic that indicates the traffic is on the ground will not be displayed or generate an alert. This is the only method used to determine whether Mode S traffic is on the ground.

***NOTE:** The system does not indicate to the crew which traffic targets are Mode S equipped.*

Radar Altimeter

Radar altitude, if available, may be used to determine which traffic targets are on the ground. For example, if the current radar altitude is 1000 feet, then traffic with a relative altitude of -1000 feet would be considered to be on the ground and would not be displayed or alerted on. Ground traffic is only filtered when the radar altitude is less than 1,700 feet.

Calculated Height Above Ground

If radar altitude is not available, calculated height above ground may be used to filter out ground traffic. Calculated height above ground is used similarly to how radar altitude is used. Ground traffic is only filtered when the calculated height above ground is less than 1,700 feet.

ADS-B Receiver

A 1090 MHz Extended Squitter (1090ES) receiver is built in to the GTS System Processor. ADS-B Out broadcasts from other traffic may include additional information such as flight ID, position, altitude, velocity, and direction. These broadcasts from other aircraft are correlated with active transponder replies. The accuracy of the ADS-B broadcasts and additional information allows for improved accuracy and other enhancements to the traffic display. Refer to the traffic display documentation for information on display enhancements for ADS-B traffic.

NOTE: The ADS-B receiver is a 1090ES receiver and cannot receive 978 MHz UAT broadcasts.

Air-to-air broadcasts from other aircraft equipped with 1090ES ADS-B Out are used for traffic correlation. Traffic or weather uplinks from ADS-B ground stations are not used. ADS-B broadcasts must be correlated with an active transponder reply in order to be shown on the traffic display. Uncorrelated ADS-B broadcasts are not used, and ADS-B correlation is not used for Traffic Advisories.

The ADS-B receiver functionality is optional and requires GPS and magnetic heading interfaces to perform the correlation function.

Self-Test

NOTE: *Traffic surveillance is not available during the self-test.*

The self-test mode is used to verify that the system is functioning normally. Self-test must be manually initiated from the Standby mode and takes approximately ten seconds to complete. During the self-test, a pattern of traffic symbols is shown on the traffic display. The test pattern consists of the following traffic:

- A Traffic Advisory at 9 o'clock, 2 miles, 200 feet below and climbing. There is no Traffic Advisory aural alert for this test traffic.
- A Proximity Advisory at approximately 1 o'clock, 3.6 miles, 1000 feet below and descending.
- Other Traffic at approximately 11 o'clock, 3.6 miles, 1000 feet above and level.

Figure 8 Self-Test Mode

If the self-test is successful, the aural announcement "[TAS / TCAS I] System Test Passed" (depending on the system type) will be played. If the self-test is unsuccessful, the aural announcement "[TAS / TCAS I] System Test Failed" will be played.

The system may be installed so that the self-test cannot be initiated while airborne.

Q AND A

What are the benefits of ADS-B?

1090 MHz Extended Squitter ADS-B data contains additional information about a target aircraft including flight ID, latitude, longitude, barometric and geometric altitude, velocity, and direction.

This provides precise location information about the target aircraft. Targets within the active surveillance range that are correlated with ADS-B data are displayed with much greater accuracy as a result of this.

When is ADS-B (passive surveillance) available?

Passive surveillance functionality is available for traffic that is equipped with 1090 MHz Extended Squitter (1090ES) ADS-B Out capability. Additionally, the GTS Traffic System must be installed with the optional GPS and magnetic heading interfaces.

How is ADS-B data used?

The GTS Traffic System correlates range, altitude, and bearing data from transponder replies with 1090ES ADS-B Out broadcasts from other aircraft, using the precision information from ADS-B to improve the quality and accuracy of the traffic information.

How are active and passive targets displayed?

A traffic target is always displayed as a single symbol, whether or not passive ADS-B surveillance is available.

Some displays may enhance the depiction of traffic that includes ADS-B information, including the Flight ID (callsign), heading, velocity, and air/ground status of the traffic.

Refer to the traffic display documentation to determine the capabilities of each display.

What capabilities does GPS data provide?

GPS data is required for the ADS-B passive surveillance feature. GPS data is also used in some installations for air/ground detection, automatic mode switching, and calculated height above ground.

GPS data is optional and the system can provide active traffic surveillance with or without GPS data.

What kind of transponder is required for use with the GTS Traffic System?

All installations except the GTS 800 require the use of a compatible Mode S transponder. The transponder provides an indication of how many other TCAS-equipped aircraft are nearby, so that the GTS traffic system can adjust its transmit power and reduce frequency congestion.

The GTS 800 does not require a transponder interface (regulatory requirements for transponder usage still apply).

Is ADS-B Out required with the GTS Traffic System?

No. The ADS-B Passive Surveillance feature uses 1090ES ADS-B Out broadcasts from other aircraft, but the ownship is not required to be equipped with ADS-B Out.

GLOSSARY

Active Surveillance:	Tracking of traffic targets using aircraft transponders
ADS-B:	Automatic Dependent Surveillance – Broadcast
ATCRBS:	Air Traffic Control Radio Beacon Service - A surveillance system that uses active interrogations and Mode A/C replies from transponders
CLEAR CAS:	Correlated Location Enhanced ADS-B Receiver Collision Avoidance System
GPS:	Global Positioning System
MHz:	MegaHertz - A unit of measure for radio frequency
Mode A:	A type of ATCRBS transmission which requests (via Mode A interrogations) or reports (via Mode A replies) aircraft identity information
Mode C:	A type of ATCRBS transmission which requests (via Mode C interrogations) or reports (via Mode C replies) aircraft altitude information
Mode S:	A type of secondary surveillance radar transmission which contains a unique 24-bit discrete address, thus allowing interrogations to be addressed to individual aircraft. Mode S transmissions can be short (56 bits) or long (112 bits), with long transmissions containing a 56-bit "message" field.
NM:	Nautical Mile
OT:	Other Traffic (other than TA or PA traffic)
PA:	Proximity Advisory
Passive Surveillance:	Tracking and enhancement of traffic targets using ADS-B broadcasts
TA:	Traffic Advisory
TAS:	Traffic Advisory System
TCAS:	Traffic Alert and Collision Avoidance System

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